METHOD AND APPARATUS FOR CEMENTING PIPE IN OIL AND GAS WELLS

This invention is in the field of wells especially oil and gas wells and in particular relates to a method and apparatus for the anchoring of a pipe in a ground hole using cementitious material.

BACKGROUND

In wells such as oil and gas wells, casings pipes are cemented into place by placing cement in the annulus between the bore of the well and the outside of the pipe. Conductor pipe is the casing string that is usually put into the well first, to support the surface formations and to prevent the walls of the open hole from washing out or caving in. It is typically from 40 to 100 feet in length and is typically 16-36 inches in diameter. It is especially necessary when drilling in sand formations or permafrost or as a flow divertor for shallow gas formations close to the surface.

A conventional method of fixing a conductor pipe in a well involves inserting the conductor pipe into the hole such that an annular space is created between the outside of the conductor and the inside wall of the well hole. Cement slurry or some other

substance sufficient for fixing the conductor pipe to the inside walls of the well hole is then poured into this annular space.

This method has many disadvantages including the inability to easily determine when the cement has completely filled the annular space and the risk of the cement slurry not filling the annular space evenly leaving air spaces and voids.

Another method that has been used to attempt to overcome the disadvantages of the above described method has involved pumping cement slurry down the conductor pipe and back up the outer annular space between the walls of the well and the outside of the conductor pipe. The conductor pipe is inserted into the well, leaving a gap between the bottom of the conductor pipe and the bottom of the well. The top of the pipe is then sealed with a welded cover plate that has a throat through which cement slurry can be pumped into the conductor pipe. Next, cement is pumped through the throat in the cover plate and into the conductor pipe. The cement slurry substantially fills the inside of the conductor pipe and flows out a gap between the bottom of the conductor pipe and the bottom of the well. The pumping continues, forcing the cement slurry up the annular space between the inside of the well bore and the conductor pipe, until cement slurry can be seen at the ground surface. The conductor pipe at this point is substantially filled with cement slurry and this cement slurry is typically displaced from the conductor pipe by pumping water into the opening on the cover plate or left to set and drilled out at a later

time. The cement slurry is displaced up the outer annular space and out of the outer annular space onto the ground surrounding the pipe.

The conductor pipes typically ranges in length from 40 to 100 feet and are usually 16 to 36 inches in diameter. Using the above method, the conductor pipe is substantially filled with cement slurry and the outer annular space between the pipe and the walls of the open hole are filled. This is a significant amount of cement slurry. This cement slurry must be displaced or drilled out from the conductor pipe before the well can be used. Using the above outlined method this displaced cement ends up spread out on the ground surrounding the top end of the pipe. This results in a waste of a significant amount of costly cement.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method of fixing pipe in wells that overcomes problems in the prior art.

It is a further object of the present invention to provide such a method that fixes a pipe with cementitious material and requires significantly less cementitious material than the prior art method.

It is a further object of the present invention to provide such a method that reduces the amount of cement left on the site.

It is a further object of the present invention to provide an apparatus that seals the end of a pipe such as a well casing or conductor pipe.

The invention provides, in one embodiment, a method for fixing a first pipe in an open hole in the ground by filling an outer annular space between the outside of the first pipe and walls of the open hole with cementitious material. The first step of the method involves placing the first pipe in the open hole such that a gap is provided to allow cementitious slurry and water to flow from a bottom end of the first pipe into the outer annular space. Next the top end of the first pipe is sealed with a cover plate, wherein the cover plate is provided with a throat therethrough.. A second pipe is then inserted through the throat such that a bottom end of the second pipe is in proximity to the bottom end of the first pipe and a top end of the second pipe is above the cover plate, whereby an inner annular space is created between an outside of the second pipe and an inside of the first pipe. The second pipe is then sealed in the throat and the inner annular space is substantially filled with water. Cementitious slurry is pumped into the top end of the second pipe such that the cementitious slurry exits the bottom end of the second pipe and passes through the gap into the outer annular space and moves upward through the outer

annular space pushing water up and out of the outer annular space, and continuing pumping until the outer annular space is substantially filled with cementitious slurry. The cementitious slurry is then allowed to set and the second pipe can be removed.

In a second embodiment the invention provides a sealing apparatus for sealing an end of a pipe and comprises: a cover plate adapted to cover the end of the pipe; and, an inflatable seal attached to the cover plate and adapted to mate to an inside rim of the pipe. The inflatable seal can be inflated with a fluid to seal the cover plate to the end of the pipe and deflated to remove the cover plate from the end of the pipe.

DESCRIPTION OF THE DRAWINGS

While the invention is claimed in the concluding portions hereof, preferred embodiments are provided in the accompanying detailed description which may be best understood in conjunction with the accompanying diagrams where like parts in each of the several diagrams are labeled with like numbers, and where:

Fig. 1 illustrates an apparatus practicing the method of the present invention;

Fig. 2 shows a cut-away diagram of a sealing apparatus;

Fig. 3 illustrates a preferred method of sealing a pipe using a sealing apparatus when a liquid is used to inflate the inflatable seal; and

Fig. 4 illustrates another embodiment of the seal apparatus incorporating a tightener.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Fig. 1 illustrates an apparatus practicing the method of the present invention. The present invention is directed to a method for fixing a first pipe [1] in an open hole [32] in the ground by filling an outer annular space [20] between the outside of the first pipe [1] and walls [33] of the open hole [32] with cementitious material.

The first pipe [1] to be affixed to walls [33] of an open hole [32] can be any type of suitable material and has a top end [3] and a bottom end [5]. First, the first pipe [1] is placed in the open hole [32] in the ground such that a gap [19] is formed between the bottom end [5] of the first pipe [1] and the bottom of the open hole [32]. When the first pipe [1] is placed in the open hole [32], an annular outer space [20] is formed between the walls [33] and the outside of the first pipe [1].

Next, a cover plate [6] is placed on the top end [3] of the first pipe [1] and sealed in place.

A throat [7] is provided passing through the cover plate [6] into the first pipe [1], through which, the second pipe [11] can be inserted. The cover plate [6] is also provided with a corresponding annulus aperture [9] and valve [10].

A second pipe is provided [11]. The second pipe [11] has a smaller diameter than the first pipe [1] and is typically made of PVC piping, however, any suitable material can be used. The second pipe [11] has a top end [13] and a bottom end [15]. The second pipe [11] is inserted through the throat [7] on the cover plate [6] and into the inside of the first pipe [1] such that the bottom end [15] of the second pipe [11] is in proximity to the bottom end [5] of the first pipe [1] and the top end [13] of the second pipe [11] is above the cover plate [6]. Inserting the second pipe [11] through the throat [7] and into the first pipe [1] creates an inner annular space [21] between the outside of the second pipe [11] and the inside of the first pipe [1] that is in communication with the annulus aperture [9]

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Typically, the second pipe [11] includes couplers [27] with conventional right hand threads connecting pipe sections [26] together to form the second pipe [11]. Using these couplers [27], a first pipe section [26] can be inserted in the throat [7] and lowered into the first pipe [1]. When the end of the first pipe section [26] is reached, a coupler [27] is used to attach another pipe section [26]. As each end of pipe section [26] is reached, another pipe section [26] is attached using a coupler [27] until the second pipe [11] is the desired length.

Once the bottom end [15] of the second pipe [11] is in the proximity of the bottom end [5] of the first pipe [1], leaving a space between the bottom end [15] of the second pipe [11] and the bottom of the open hole [32], the second pipe [11] is sealed in the throat [7]. The second pipe [11] is sealed in the throat [7] of the cover plate [6] using any suitable method including the conventional methods using landing nipples and o-rings, which are well known in the art.

Next the inner annular space [21] is substantially filled with water. A manifold [16] is connected to the second pipe [11]. In Fig. 1, the manifold [16] illustrated therein is commonly known in the art and allows either a cementitious slurry or water to be pumped through the manifold [16] without disconnecting the manifold from the second pipe [11], but any manifold [16] which can be connected to the second pipe [11] and allows cementitious slurry to be pumped into the second pipe [11] is contemplated.. The manifold [16] is attached to the top end [13] of the second pipe [11]. The valve [10] of the annulus aperture [9] is opened and water is pumped through the manifold [16] down into the second pipe [11]. The water will fill flow out the bottom end [15] of the second pipe [11] into the inner annular space [21] and through the gap [19] and into the outer annular space [20]. As the water continues to be pumped into the second pipe [11] the water will rise up the outer annular space [20] and rise up the inner annular space [21] forcing the air in the inner annular space [21] out of the annulus aperture [9]. Water is pumped into the second pipe [11] until the inner annular space [21] is substantially filled with water. This can be approximately determined by water being visible at either the ground surface around the outside of the first pipe [1] or at the annulus aperture [9].

When the inner annular space [21] is filled with water, the valve [10] of the annulus aperture [9] is closed.

Cementitious slurry is then pumped into the the top end [13] of the second pipe [11]. The cementitious slurry will pass down the second pipe [11] and out of the bottom end [15] of the second pipe [1] to the bottom of the open hole [32]. Because the inner annular space [21] is filled with water and sealed by the cover plate [6], the cementitious slurry will pass through the gap [19] and up the outer annular space [20], pushing water up the outer annular space [20] as it goes. Once the cementitious slurry can be seen at the ground surface between the first pipe [1] and the wall [33] of the open hole [32], the outer annular space [20] is substantially filled with cementitious slurry and no more cementitious slurry needs to be pumped down the second pipe [11].

At this point, the volume of excess cementitious slurry is equal to the internal volume of the smaller second pipe [11] rather than the internal volume of the much larger first pipe [1], which it would in the conventional method of the prior art.

At this time the cementitious slurry can be left to set and the second pipe [11] removed after the cementitious material has set.

To facilitate removal of the second pipe [11] it is convenient to displace the cementitious slurry out of the second pipe [11] before it sets. The second pipe [11] is conveniently provided with a plug receiver [23] at the bottom end [15] that is adapted to

receive a plug [25]. A plug [25] is also provided that is the approximate cylindrical in shape with a diameter approximately equal to the inside diameter of the second pipe [11]. The plug [25] and plug receiver [23] are used to displace the cementitious slurry out of the inside of the second pipe [11] before the cementitious slurry sets. Once the cementitious slurry has filled the outer annular space [20] the plug [25] is placed in the second pipe [11] and forced down the second pipe [11] by pumping water into the second pipe [11] behind the plug [25]. As the plug [25] is forced down the second pipe [11] by the water, it will displace the cementitious slurry out the bottom end [15] of the second pipe [11]. When the plug [25] reaches the plug receiver [23] at the bottom end [15] of the second pipe [11] substantially all of the cementitious slurry will be displaced out of the second pipe [11] and the plug [25] will land in the plug receiver [23] where it will remain.

In the illustrated embodiment, the second pipe [11] is provided with a detachable bottom end section [28], which is conveniently attached to the second pipe [11] by a coupler [27] having a right hand thread screwed onto the second pipe [11] and a left hand thread screwed onto the detachable bottom end section [28]. Once the cementitious slurry sets, the detachable bottom end section [28] may be fixed in the cementitious material at the bottom of the open hole [32]. By rotating the second pipe [11] and loosening the left hand thread screwed onto the detachable bottom end section [28], while at the same time keeping the right hand thread connected to the second pipe [11], the second pipe [11] is uncoupled from the detachable bottom end section [28]. In this manner, the second pipe [11] can be removed leaving behind the detachable bottom end

section [28] which is likely fixed in the set cementitious material at the bottom of the open hole [32], rather than having to break the bottom end [15] of the second pipe [11] out of the set cementitious material at the bottom of the open hole [32].

The water in the inside annular space [21] can be removed in a number of different ways including simply pumping it out the inner annular space [21]. If it is desired to remove the water immediately a pump can be attached to the second pipe [11] and the water pumped out of the inner annular space [21]. Another method of removing the water from the inside annular space [21] involves pumping air into the inner annular space [21] and forcing a substantial amount of the water out the top end [13] of the second pipe. The second pipe [11] is removed from the set cementitious material at the bottom of the open hole [32] or uncoupled from the detachable bottom end of the section [28]. Next, the valve [9] of the annulus aperture [10] is opened and air is pumped into the annulus aperture [9]. The air forces the water in the inner annular space down and into the bottom end [15] of the second pipe [11], up the second pipe [11] and out the top end [13] of the second pipe. In this manner, a substantially amount of the water in the inner annular space [21] can be removed.

The contemplated invention includes sealing the top end [3] of a first pipe [1]. The cover plate [6] could be attached to the top end [3] of the first pipe [1] by any conventional means including welding, but the cover plate illustrated in all of the Figs. is a sealing apparatus [100].

Fig. 2 shows a cut-away of a sealing apparatus [100]. The illustrated sealing apparatus [100] comprises a cover plate [101], an inflatable seal [103], first aperture [104], a first valve [105], a second aperture [106] and a second valve [107].

The cover plate [101] is adapted to fit over the top end [3] of the first pipe [1]. The inflatable seal [103] fits inside the rim of the top end [3] of the first pipe [1] and is inflated with a fluid. The first aperture [104] passes through the cover plate [101] and into the inflatable seal [103] and can be opened and closed by the first valve [105]. The second aperture [106] passes through the cover plate [101] and into the inflatable seal [103] at the opposite side of the inflatable seal [103] and can be opened and closed by a second valve [107]. The inflatable seal [103] can be any suitable structure capable of expanding and containing a fluid, including a tire. The inflatable seal [103] can be inflated by opening the first valve [105] and forcing a fluid through the first aperture [104] and into the inflatable seal [103]. The sealing apparatus [100] can be removed from the top end [3] of the first pipe [1] after it is no longer needed to seal the top end [3] by opening the first valve [105] and allowing the inflatable seal [103] to deflate. The inflation of the inflatable seal [103] allows the sealing apparatus [100] to adaptively seal pipes with varying wall thicknesses or are out of round.

Fig. 3 illustrates a preferred method of sealing a pipe using the sealing apparatus [100] and a liquid is used to inflate the inflatable seal [103]. A liquid tank [109] partially filled with a liquid, leaving an air pocket [110] at the top of the liquid tank [109], is attached to the first aperture [104]. A vacuum is applied to the air pocket [110] causing

the inflatable seal [103] to deflate and facilitating it being inserted into the top end [3] of the first pipe [1]. The sealing apparatus [100] is then positioned on the top end [3] of the first pipe [1] and the second valve [107] is opened. Air is then forced into the liquid tank [109] causing the air pocket [110] to expand and forcing the liquid through the first aperture [104] and into the inflatable seal [103]. Whatever air that is in the inflatable seal [103] will be forced by the liquid out of the second aperture [106]. Once the liquid can be seen coming out of the second aperture [106], the second valve [107] can be closed and the liquid can be continued to be pumped into the inflatable seal [103] until the sealing apparatus [100] is sufficiently sealed to the top end [3] of the first pipe [1].

Referring still to the embodiment of the apparatus shown in Fig. 3, the sealing apparatus [100] can be removed when it is no longer needed by once again applying a vacuum to the air pocket [110] of the liquid tank [109] and deflating the inflatable seal [103]. The sealing apparatus can than be removed from the top end [3] of the first pipe [1].

Referring again to Fig. 2, the sealing apparatus [100] can be provided with a safety clamp [108]. The safety clamp [108] preferably comprises a collar [113] secured to the outside rim of the top end [3] of the first pipe [1]. The collar [113] would typically be a dog collar as is known in the present art. The collar [113] is attached to the cover plate [101] by a tether [111] which is typically a number of chains, but could be anything of suitable strength to hold the sealing apparatus [100] on the top end [3] of the first pipe [1]. In a preferred embodiment, the tether [111] provides some slack when attached to

the collar [113] and the cover plate [101] to allow the sealing apparatus [100] to act as a crude pressure release valve should the pressure in the first pipe [1] become great enough to overcome the seal formed by the sealing apparatus [100].

Fig. 4 illustrates another embodiment of the seal apparatus incorporating a tightener [112]. In this embodiment, the tightener [112] is attached between the cover plate [101] and tether [111]. The tightener [112] is typically a bolt and matching nut. The tightener [112] can be tightened to pre-tension the tethers [111] and hold the cover plate [101] on the top end [3] of the first pipe [1] before the inflatable seal [103] is inflated.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous changes and modifications will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all such suitable changes or modifications in structure or operation which may be resorted to are intended to fall within the scope of the claimed invention.